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# Simple Guide to Fluid and Electrolyte Balance in Relation to Surgery

BY

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The rapid advances in surgery and anaesthetics are making more extensive surgical procedures possible and allowing more "poor risk" patients to be operated on with a reasonable chance of survival.

An important advance has been the understanding of the changes in the fluid and electrolyte balance which occur after surgery and in surgical conditions. This is of great value in patients who have to be fed by the intravenous route for some days after extensive intra-abdominal procedures.

We have used the following simple guide at Roan Antelope for the last three years with considerable success. It is an easy regime to follow and is easily understood by all concerned in looking after the patient. It is, however, a simple guide and deliberately excludes many very important aspects of the problem. In particular, the possibility of disturbances in acid-base relationships must be borne in mind by those in attendance on the patient.

## Normal Requirements

A healthy adult indulging in no strenuous physical activity requires the following in this climate:—

Water: ± 3 litres; 6 pints.
Saline (NaCl): ± 9 gm. contained in two pints normal saline.
Potassium (KCl): 4-8 gm.
Also—
Calories: 15-25 calories per lb. body weight.
Protein: 1 gm. per lb. body weight.

} Per 24 hours.

The basic fluid and electrolyte requirements are necessary to maintain the correct "internal environment" of the body and to ensure an adequate urine output in addition to the other routes by which fluid is lost from the body. These are:—

(1) *Saturating Inspired Air with Water.*—
The amount lost is dependant on the humidity of the atmosphere and air temperature. It bears no relation to the amount of fluid available in the body.

(2) *Sweating.*—
This is a cooling mechanism in which water and salt are lost. The amount lost depends on body temperature and proceeds regardless of amount of salt and fluid available.

} *At Rest* 7-10 c.c. per lb. body weight per 24 hours, depending on air temperature and humidity.

(3) *Faeces.*—
The amount lost depends to what extent water can be re-absorbed by the colon and rectum. Low water loss in constipated stool ± 300 c.c. daily. High water (and sodium) loss in diarrhoea.

(4) *Urine Output.*—
This is the only source of fluid loss which can be varied by the body. The blood volume must be kept constant. Excess fluid can be disposed of by increasing the volume of urine excreted or deposited in tissue spaces. This latter, if excessive, will produce oedema.
The kidneys also have to excrete waste products and so there is a definite lower limit of urine volume. This is 500 c.c. of urine per 24 hours, provided S.G. of 1030 can be reached.
If the kidneys are unhealthy and cannot concentrate to 1030, more than 500 c.c. of urine must be excreted to clear metabolic end-products adequately.
A urine output of 1,000 c.c. or above daily with an S.G. below 1020 is what should be aimed at.

## Disturbances of Normal State

I. *After Operation*
After *any* operation certain changes occur:
(1) There is a retention of sodium (Na+) and chloride (Cl—). This usually lasts for 24

hours or so, but may last a week. Caution must be exercised, therefore, in giving sodium and chloride in this period.

(2) There is a decreased urinary output for 24 hours or so, which is followed by a diuresis. The decreased urinary output *cannot* be increased by increasing the amount of fluid available in the body. Forcing oral and/or I.V. fluids at this stage will only lead to oedema and even pulmonary oedema.

(3) There is excessive potassium (K+) loss after operation followed by retention. As a rule there is no need to replace potassium for the first 72 hours after operation unless there is abnormal loss. This may well occur with massive gastric fluid loss by nasogastric suction or excessive vomiting.

II. *Excessive Loss*

In many diseases the fluid loss by the body is considerably increased, e.g.:—

(1) Intestinal obstruction—
  (i) Fluid in distended bowel.
  (ii) Vomiting.
(2) Prolonged vomiting from any cause.
(3) Diarrhoea.
(4) Drainage tubes and fistulae.
(5) Burns—loss of protein ++ and fluid.

### CONTROL OF FLUID ADMINISTRATION

The best method of giving fluids is by mouth, as the body then absorbs only what is required. Provided adequate quantities of fluid and electrolytes can be absorbed, the oral route should always be used.

When the oral route is impracticable the I.V. route is to be used.

In order to give fluids intravenously, certain points must be remembered:—

(1) An accurate record of total intake (both type of fluid and quantity) and total loss by the various routes is essential. Without such a record, proper control is impossible. The S.G. of all specimens of urine must be accurately measured and recorded.

(2) A knowledge of the underlying disturbances of the disease for which the patient is being treated is essential, e.g., you must know not to force fluids immediately after operation, when to give potassium, etc.

(3) It is impossible to give adequate quantities of carbohydrate (for calories) and protein by the intravenous route. Therefore there will be a calorie deficit and increased breakdown of body proteins as long as a patient is on intravenous fluids. All I.V. fluids should, therefore, be on a basis of 5 per cent. dextrose in water solutions in order to give as much carbohydrate as possible.

(4) Potassium intravenously is very dangerous. It must never be given unless the urine output with healthy kidneys is above 700 c.c. daily without laboratory control. Ideally, potassium should never be given I.V. without laboratory control.

(5) More than four successive pints of 5 per cent. dextrose in normal saline should never be given. The fifth pint should be 5 per cent. dextrose in $H_2O$. If this is not done the blood plasma will be made hypertonic.

### DETERMINATION OF FLUID TO BE GIVEN

*First Day*

You will either be dealing with a healthy patient who has had an operation on this day or a patient who has lost fluid and electrolytes from his disease. This latter is to be tackled as for the second and subsequent days.

*Post-Op. Case* (all figures for adults).—Basic requirement for coming 24 hours:

| | |
|---|---|
| Five per cent. dextrose in water ..... ..... | 4 pints |
| Five per cent. dextrose in normal saline | 2 pints |

But there is fluid and sodium retention in first 24 hours post-op., so—

(1) Reduce saline to one pint, unless—
  (i) weather is very cold and sweating will be minimal—give no saline at all;
  (ii) excessive loss of saline is anticipated over 24 hours—increase amount to be given.
(2) Reduce total fluid intake to 4-5 pints, depending on external temperature.
(3) All operative losses, especially of blood, must be restored; therefore add these to 4-5 pints basic.

*Second Day*

| | |
|---|---|
| Basic requirements of fluid ..... ..... | 6 pints |
| Basic requirements of NaCl ..... ..... | 2 pints |

Therefore give four pints 5 per cent. dextrose in $H_2O$ and two pints 5 per cent. dextrose in normal saline. To this must be added:

(1) The deficit from the previous 24 hours (remember to include loss by sweating 7-10 x body weight in lb. when assessing daily loss).
(2) The anticipated losses over the next 24 hours, e.g., nasogastric suction, fistula, etc. Nasogastric suction must be replaced pint for pint by 5 per cent. dextrose in normal saline which must be added to the basic level.

BUT—

In post-operative cases never force fluids until urine volume starts rising and S.G. is falling.

*Third Day*

As above.

In post-operative cases a potassium blood level should be done, as administration of K+ may now be necessary.

In non-operative cases or cases of intestinal obstruction before operation, K+ may have to be given right from the start. *N.B.*: No K+ to be given I.V. unless urine output is adequate.

### ASSESSMENT OF PROGRESS

(1) *Clinical*

(i) State of the tongue—dry or moist.

(ii) Presence of oedema or loss of skin elasticity.

(iii) Total daily urine output and S.G. As long as output is above 900 c.c. with healthy kidneys, progress is satisfactory.

(iv) The state of the lung bases. Pulmonary oedema which can be fatal, especially in the elderly, is often the first sign of excessive I.V. fluid administration. The chest must be auscultated at least once daily in any patient receiving intravenous fluids.

(2) *Laboratory*

Accurate daily estimations of plasma electrolyte and protein levels are very valuable when considered together with an *accurate* clinical record.

Beware of apparently satisfactory electrolyte levels with a high protein level. This indicates haemocentration. When rehydration occurs, these apparently satisfactory levels may fall to dangerously low levels by dilution. When rehydrating, always replace electrolytes proportionately.

### CHILDREN

All the foregoing applies to children, but the quantities must be reduced.

(1) *Fluid Requirements per 24 hours*
(B.W. equals body weight)

(i) Infants (up to 22 lb.): 80-55 c.c. per lb. B.W.

(ii) Children (25-90 lb.): 50-25 c.c. per lb. B.W.

(iii) Adults (above 100 lb.): 17 c.c. per lb. B.W.

(2) *Calories*

(i) Infants: 30 calories per lb. B.W.

(ii) Children: 20 calories per lb. B.W.

(3) *Urine Output*

(i) Infants: 300 c.c. daily.

(ii) Children: 600 c.c. daily.

(iii) Adults: 900 c.c. daily.

At the figures as above, fluid balance is quite satisfactory.

### SOME USEFUL FIGURES

*Plasma Electrolytes*

(i) Sodium: 135-145 m. Eq./Litre.

(ii) Potassium: 3.5-5.5 m. Eq./Litre.
Fatal level is 8-10 m. Eq./Litre.

(iii) Chloride: 95-105 m. Eq./Litre.

*Proteins*

Total: 6.5-8 gm. per cent.

*Urine*

(i) Sodium: 135-145 m. Eq./Litre.

(ii) Potassium: 30-40 m. Eq./Litre.

(iii) Chloride: 95-105 m. Eq./Litre.

These figures can be varied considerably by the kidneys.

### USEFUL METHOD OF GIVING ELECTROLYTES

*Saline*

(i) If no abnormal saline loss:
Two pints 5 per cent. dextrose in water to one pint 5 per cent. dextrose in normal saline.

(ii) If moderate abnormal saline loss:
Alternate 5 per cent. dextrose in water and 5 per cent. dextrose in normal saline with increased total daily intake.

(iii) If severe abnormal saline loss:
Two pints 5 per cent. dextrose in normal

### GASTRO-INTESTINAL SECRETION

| Type | Daily Output | m. Eq./Litre of Secretion | | |
|---|---|---|---|---|
| | | Na+ | K+ | Cl— |
| (i) Gastric juice | 2,500 ml. | 60 | 10 | 90 |
| (ii) Pancreas | 1,000 ml. | 150 | 5 | 80 |
| (iii) Bile | 700-1,000 ml. | 150 | 5 | 100 |
| (iv) Small bowel | 3,000 ml. | 100 | 10 | 70 |

saline to one pint 5 per cent. dextrose in $H_2O$ with markedly increased total daily intake.

*Potassium*

We use a solution of potassium chloride and ammonium chloride for giving potassium intravenously. This is made up as a concentrated solution of—

5 gm. $NH_4Cl$
4.49 gm. KCl
Dissolved in 50 c.c. water.

On dilution to 500 c.c. this gives a solution of 1 per cent. $NH_4Cl$ and 0.89 per cent. KCl administered in 500 c.c. 5 per cent. dextrose in water.

This is adequate for a normal 24-hour intake. This is best given in two 25 c.c. lots in two alternate bottles of I.V. fluid to avoid injury to the vessel wall. Each case must be considered on the observed and anticipated changes for the particular case.

## EXAMPLES

### I. *Gastrectomy*

Fit before operation. Weight, 150 lb.

(1) *Day of Operation*

(a) Fluids given—

| | | |
|---|---|---|
| (i) Whole blood (contains saline) | 540 | |
| (ii) Five per cent. dextrose in water, 4½ pints | 2,430 | |
| (iii) Oral | — | |
| TOTAL INTAKE | | 2,970 |

(b) Losses—

| | | |
|---|---|---|
| (i) Haemorrhage at operation and exposed bowel (2½ hour op.) | 1,000 | |
| (ii) Insensible loss (hot day) | 1,500 | |
| (iii) Urine | 300 | |
| (iv) Nasogastric suction | 500 | |
| | | 3,300 |
| DEFICIT | | 330 |

(2) *First Post-Op. Day. Losses to be made good*

| | |
|---|---|
| (i) Deficit from previous 24 hours | 330 |
| There was 500 c.c. gastric suction, so this must be given as normal saline. | |
| (ii) Anticipated losses over next 24 hours from nasogastric suction | 200 |
| (iii) Basic requirements | 3,000 |
| TOTAL | 3,530 |

Provided urine S.G. is falling, the whole of this can be given in 24-hour period to follow, so 5 per cent. dextrose is given alternately in normal saline and 5 per cent. dextrose in $H_2O$. Total I.V. intake to be 6-7 pints.

(3) *Second Post-Op. Day*

As above. Oral fluids may possibly now be given. Urine output should be rising with falling S.G. Potassium may have to be given. Check with plasma levels.

### II. *Intestinal Obstruction*

Two days' duration before laparotomy.
Weight, 150 lb.

(1) *Day of Operation*

An attempt should be made to get basal electrolyte level before operation, as the picture is probably disorganised.

The deficit may be in the region of 4,000 to 5,000 c.c. However, care must be used in replacing fluids for the first day.

About 5-6 pints are given I.V. alternate 5 per cent. dextrose in water and 5 per cent. dextrose in normal saline if there has been a lot of vomiting. If there is not much vomiting, only two pints 5 per cent. dextrose in water to one pint 5 per cent. dextrose in normal saline are given.

(2) *First Post Op. Day*

Deficit in pre-operative deficit plus or minus deficit of day of operation.

Once urine output is increasing, rapid restoration of fluid and electrolytes must be carried out. Laboratory control is invaluable in this type of case, as the losses are never simple fluid and salt disturbances.

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